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The relation between teachers' emphasis on the development of students' digital information and communication skills and computer self-efficacy: the moderating roles of age and gender

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Abstract

Teachers' integration of information and communication technology (ICT) has been widely studied, given that digital competence is considered to be a crucial outcome of twenty first century education. In this context, research highlighted teachers' computer self-efficacy (CSE) as one of the most important determinants of their ICT integration into teaching practices. Whereas previous research mainly focused on the relation between CSE and ICT integration from a frequency-based point of view, recent research suggests to investigate this relation using more qualitative measures of ICT integration such as the degree to which teachers emphasize developing students' digital information and communication skills (TEDDICS). Consequently, the present study investigates the relations between these two constructs: teachers' emphasis on developing students' digital skills and their computer self-efficacy, taking into account the moderating roles of age and gender. We used a representative sample of 1071 Norwegian secondary school teachers who participated in the international computer and information literacy study (ICILS) in 2013. Our results provide evidence on the positive relation between CSE and TEDDICS. Furthermore, age positively moderated this relation between some factors of the two constructs, indicating that computer self-efficacy plays an even more important role for teachers of higher age in the context of emphasizing ICT skills in classrooms. The unique effect of gender was present for one correlation between CSE and TEDDICS, indicating that moderation by gender was apparent to a limited extent, and related to use of computers for instructional purposes. The interaction between age and gender did not reveal significant moderation effects. We discuss these results in light of the potential consequences for teacher training.

Keywords: Age and gender differences, Computer self-efficacy, Emphasis on digital skills [TEDDICS], ICILS 2013, Moderation, Teachers' ICT integration

Introduction

The role and use of information and communication technology (ICT) in education has changed profoundly over the last decade. This change is evident at many levels in education, for instance, with respect to the availability of ICT resources at schools, the access to internet, and the transition from paper-and-pencil to computer-based exams (Scherer and Siddiq 2015a; Scheuermann and Pedró 2009). Furthermore, students' digital competence has gained substantial attention and is considered to be an important twenty first century skill (Griffin et al. 2012). As a consequence, a first line of research studied the determinants of teachers' integration of ICT into classroom activities (Tondeur et al. 2008), given that the teachers play a key role in developing students' digital skills (Schibeci et al. 2008). Specifically, teachers' computer self-efficacy (CSE) has been identified as one of the most important determinants for teachers' integration of ICT in teaching and learning practices (Kreijns et al. 2013; Mumtaz 2000). Existing research identified positive relations between teachers' CSE and their use of ICT (e.g., Kreijns et al. 2013; Sang et al. 2010). It therefore seems, as if the degree to which teachers integrate ICT into their teaching depends on the beliefs in their capabilities of using ICT (i.e., self-efficacy). But these beliefs may depend on a number of factors. For instance, some research showed that teachers' age and CSE are negatively related, indicating that older teachers are less self-efficacious than their younger colleagues (e.g., O'Bannon and Thomas 2014; Vanderlinde et al. 2014). Regarding the relation between teachers' CSE and gender, there has been less consistent results depending on how CSE was measured (Ong and Lai 2006; Sang et al. 2010; Scherer and Siddiq 2015b; Sieverding and Koch 2009).

A second line of research focused on providing more fine-grained conceptualizations of ICT use that not only reflect teachers' *bare* use of ICT in classrooms, but also adds value by linking it to students' digital skills (Siddiq et al. 2016). For instance, teachers' emphasis on developing students' digital information and communication skills (TEDDICS) was introduced as a goal-oriented measure which combines teachers' use of ICT and teaching practices with their beliefs about which digital skills are considered important (Fraillon et al. 2014). In a recent study, Siddiq and Scherer (2015) showed that teachers' self-efficacy in using computers for instructional purposes and aspects of TEDDICS were positively related. However, an in-depth view concerning this relation, which accounts for further factors of CSE on the one hand and for the potential effects of age and gender on the other hand, is still lacking. Such a view may provide detailed information on how the TEDDICS-CSE relation operates in different age groups and across gender, and may help us identify potential needs for strengthening teachers' CSE and TEDDICS.

On the basis of the findings described above, we first investigate the relation between different factors of teachers' CSE and TEDDICS, and secondly, examine the moderating roles of teachers' age, gender, and their interaction for this relation. Drawing on the Norwegian sample of lower secondary school teachers who participated in the international computer and information literacy study (ICILS) in 2013, we apply structural equation modelling and moderation analyses to examine these relations.

Background

Teachers' computer self-efficacy (CSE)

Self-efficacy is defined as an individual's beliefs about his or her capabilities and levels of performance related to a course of action (Bandura 1997). In educational research, teachers' self-efficacy has been shown to play an important role in influencing their teaching practices and furthermore their students' achievement and motivation (Skaalvik and Skaalvik 2007). Teachers' *computer self-efficacy* was defined by Compeau and Higgins (1995), and refers to "an individual's perception of his or her ability to use computers in the accomplishment of a task" (p. 191). Many researchers have taken a general approach toward studying this construct, assuming that there exists a general CSE factor only, which focuses on teachers' general perceptions of their capabilities in using ICT (e.g., Durndell and Haag 2002; Teo 2014). Scherer and Siddiq (2015b) pointed out that this unidimensional view on CSE may have caused the somehow puzzling and contradictory results on the determining factors of teachers' intentions toward technology usage. Together with Lee et al. (2009), they further argued that one way to solve this conundrum is to assume that teachers do not make general decisions about the use of technology in their classrooms, but rather individual judgments about specific uses. Therefore, the ways teachers make these decisions may vary according to the different types of ICT use. This view is supported by other researchers that consider the nature of self-efficacy to be specific to situations and domains (e.g., Dicke et al. 2014; O'Mara et al. 2006). They suggested using *specific* CSE measures that reflect the targeted performance rather than *global* assessments (Bong and Skaalvik 2003; Pajares and Schunk 2001).

As a consequence, a limited number of recent studies have adopted this view by operationalizing CSE as a multidimensional construct according to the different uses of computers for *specific* teaching and learning purposes (Scherer and Siddiq 2015b). This approach is in line with the requirements in national curricula that relate to students' digital literacy as being composed of several facets (e.g., Aesaert et al. 2014; Claro et al. 2012; Ferrari 2013). We therefore consider CSE to be multidimensional and aligned with the specific facets of digital literacy.

Teachers' emphasis on developing students' digital information and communication skills (TEDDICS)

The construct 'TEDDICS' was developed in the context of ICILS 2013 (Fraillon et al. 2014). TEDDICS aims to gauge to what extent teachers' emphasize the development of students' ICT-related skills. In contrast to existing measures of teachers' use of ICT, which were mostly derived from indicators of the quantity, technology specificity, and the duration of ICT use (e.g., Akarsu and Akbiyik 2012; Hsiao et al. 2010; Yildirim 2000), TEDDICS represents a more qualitative aspect of ICT use (Fraillon et al. 2013; Siddiq et al. 2016). Furthermore, it bring together curricular demands and teachers' beliefs about the importance of digital skills, further linking it to the development of students' competence in this area (Fraillon et al. 2013).

In the twenty first century, managing digital information is regarded as a vital competence (Griffin et al. 2012). Frameworks on students' digital competence comprise several facets, and most of the frameworks share common dimensions focusing on different activities of handling digital information (e.g., searching, accessing, evaluating, sharing and communicating digital information; Claro et al. 2012; Ferrari 2013; Gallardo-Echenique et al. 2015). Moreover, since a number of studies indicated that students struggle within this area and lack skills related to information retrieval and information processing (e.g., Aesaert et al. 2014; Kuiper et al. 2005), there is a pressing need for fostering these skills in the classroom. As a consequence, focusing on TEDDICS may provide information on potential opportunities to address this need.

The assessment of TEDDICS in ICILS 2013 captured the extent to which teachers' emphasize the development of students' competencies of handling digital information (i.e., *accessing, evaluating, and sharing and communicating digital information).* This measure was scrutinized by Siddiq et al. (2016) with respect to its internal and external validity. In fact, three TEDDICS factors, each representing one of the facets of dealing with digital information were identified. Furthermore, positive relations between TEDDICS, teachers' use of ICT, and CSE in instruction were found (Ainley et al. 2015; Siddiq et al. 2016). On the basis of these findings, we argue that taking a multidimensional perspective on both CSE and TEDDICS can provide detailed information on the relation between *specific* ICT-related self-beliefs and the emphasis on developing *specific* digital and information skills in classrooms.

The roles of teachers' age and gender as potential moderators

The existing body of research identified age and gender differences in the context of technology adoption (Morris and Venkatesh 2000), information technology acceptance (Teo 2014), computer experience (Hsiao et al. 2010), and ICT integration (Cassidy and Eachus 2002). These differences may also affect the relation between TEDDICS, a construct closely related to ICT use and integration, and CSE, a construct determining the use and integration of ICT. We thus provide a brief summary of existing findings on age and gender effects in the following subsections.

Teachers' age

In the context of technology acceptance and integration of ICT into classrooms, teachers' age was identified as a potential source of variation in the constructs involved. For instance, older teachers tend to express lower levels of perceived usefulness of ICT, computer self-efficacy, and perceived ease of use than their younger colleagues (O'Bannon and Thomas 2014; Vanderlinde et al. 2014; Venkatesh et al. 2003). In line with these observations, older teachers also display higher ICT anxiety (Mac Callum et al. 2014) and emphasize problems and obstacles created by the use of ICT for teaching and learning more than younger teachers (Scherer et al. 2015).

Gender differences

Gender differences in ICT-related constructs have gained considerable attention. One reason for this attention may lie in the fact that existing studies have provided conflicting findings on both, the direction and significance of the gender effects. For instance, significant gender effects were reported for constructs such as teachers' ICT use, CSE, and perceived usefulness (e.g., Scherer and Siddiq 2015b; Volman and van Eck 2001). On the contrary, a number of studies could not identify gender differences in these constructs (Antonietti and Giorgetti 2006; Shapka and Ferrari 2003; Teo 2008). Hence, these conflicting findings require a continued focus on whether differences across gender exist for the specific constructs and samples under investigation.

Potential moderation effects

In light of the above mentioned findings on age and gender differences in ICT-related constructs, it is currently unclear whether or not the relation between CSE and TEDDICS is affected by teachers' age and gender. In research on general self-efficacy, teachers' age, gender, and main subject have been integrated as moderators. Specifically in the context of instructional self-efficacy, age and gender are considered to be moderators of different relations among classroom management, teaching effectiveness, and job satisfaction (e.g., Dicke et al. 2014; Klassen and Tze 2014). However, in the context of teachers' ICT integration in classroom practice, moderation effects of age and gender on the relation between ICT-related constructs have rarely been explored in detail (Schepers and Wetzels 2007). Thus, we cannot be certain if the TEDDICS-CSE relation is also subject to age and gender differences. In other words, potential age or gender differences in each of the two constructs may not necessarily imply differences in their relation.

The present study

This study attempts to provide a detailed view on the TEDDICS-CSE relation by using multidimensional measures of both constructs. Moreover, since it has been unclear whether this relation is robust against age and gender differences, we include these variables along with their interaction as potential moderators (see Fig. 1). Specifically, we address two research questions:

1. How does teachers' emphasis on developing students' digital information and communication skills relate to teachers' computer self-efficacy?
2. To what extent do age, gender, and their interaction (age × gender) moderate the relation between TEDDICS and CSE?

Methods

Sample and procedure

The current study is based on the Norwegian sample of secondary school teachers who participated in ICILS 2013 (Fraillon et al. 2014). In total, 1071 teachers responded to both, the TEDDICS and CSE scales, and provided information on their background (e.g., age, gender, and main subjects). Norwegian teachers were randomly sampled in a two-step procedure (step 1: sampling of schools, step 2: sampling of teachers within schools), and were based in 132 secondary schools in different municipalities across Norway. The

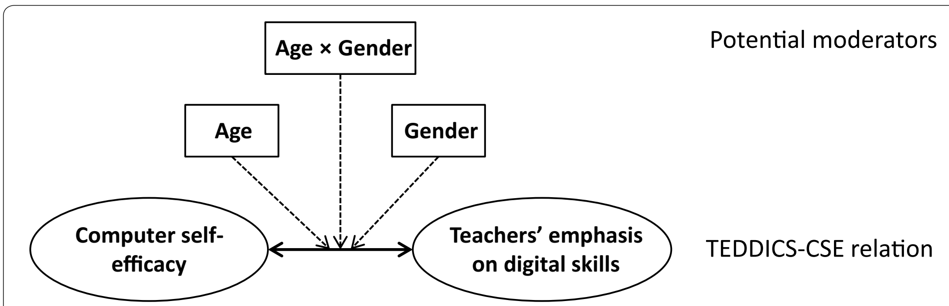

Fig. 1 Conceptual model describing the moderating role of teachers' age, gender, and their interaction for the relation between CSE and TEDDICS

sampling accounted for schools' composition, background, and socio-economic characteristics. Teachers' mean age was 44.3 years ($SD = 11.2$) and ranged between 23 and 71 years (64.2 % female teachers).

We estimated the reliability of each TEDDICS and CSE factor as McDonald's ω (Yang and Green 2011). All analyses were employed in the statistical package M*plus 7.3* (Muthén and Muthén 1998–2015).

Measures

Teachers' emphasis on developing students' digital information and communication skills (TEDDICS)

Since students' skills in accessing, evaluating, and sharing and communicating digital information are considered to be crucial factors of digital competence (Fraillon et al. 2013), we used the multidimensional measure of TEDDICS that was used in ICILS 2013 (Jung and Carstens 2015; Siddiq et al. 2016). This measure distinguishes between three factors of the construct: *'Accessing digital information'* ($\omega = .79$, 3 items), '*Evaluating digital information'* ($\omega = .90$, 4 items), and *'Sharing and communicating digital information'* ($\omega = .80$, 5 items). Teachers were asked to rate the degree to which they emphasize the development of these skills in their lessons on a 4-point scale ranging from '*0 = no emphasis*' to '*3 = strong emphasis*'. Please review the supplementary material for the item wordings and labels of this scale (see Additional file 1: A1).

Teachers' computer self-efficacy (CSE)

The assessment of teachers' CSE comprised the beliefs in their capabilities of performing specific operational tasks with the help of computers on the one hand, and using computers for instructional purposes on the other hand (Fraillon et al. 2014; Jung and Carstens 2015; Scherer and Siddiq 2015b). Specifically, teachers were asked to rate the degree to which they perceived their capabilities of performing 14 computer tasks on a three-point rating scale (*0 = I do not think I can do this, 1 = I could work out how to do this, 2 = I know how to do this*). Based on Bandura's (1997) recommendations on measuring self-efficacy, the item stimulus referred to the degree to which they believed they can do these tasks. In total, 14 items were used to measure three factors of the construct with sufficient reliabilities: Self-efficacy in basic operational skills ($\omega = .79$, 6 items), self-efficacy in advanced operational and collaborative skills ($\omega = .72$, 4 items), and self-efficacy in using computers for instructional purposes ($\omega = .76$, 4 items). The distinction between these three CSE factors has recently been confirmed empirically, and sufficient evidence on the validity of the CSE assessment was obtained (Scherer and Siddiq 2015b). Item wordings and labels used in ICILS 2013 can be found in the Additional file 1: A2.

Statistical analyses

Research question 1

In order to address our first research question on the relation between TEDDICS and CSE, we specified correlated-traits models of confirmatory factor analysis for both constructs and studied the correlation between the latent variables (Brown 2013). These models distinguished between the three TEDDICS factors (Accessing, evaluating, sharing & communicating digital information) and the three CSE factors (CSE in basic operational

ICT tasks, CSE in advanced operational ICT and collaboration tasks, and CSE in using ICT for instructional purposes), and resulted in nine correlations. In these analyses, we treated teachers' responses categorically and applied weighted least squares means and variance adjusted (WLSMV) estimation (Rhemtulla et al. 2012; Sass et al. 2014).

In order to evaluate the goodness-of-fit of the models, we examined model fit statistics such as the χ^2 value, the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the Tucker Lewis index (TLI), and applied common guidelines for an acceptable model fit: RMSEA $\leq$ .08, CFI $\geq$ .95, and TLI $\geq$ .95 (Marsh et al. 2005). We note that a significant χ^2 value indicates substantial deviations of the empirically implied model from the model that is based on the actual data. Nevertheless, this statistic might show a significant value although the model fits the data, given the relatively large sample size. As a consequence, we did not base our decision for or against a model solely on this statistic.

Research question 2

Our second research question was concerned with the moderating effects of age, gender, and their interaction on the TEDDICS-CSE relations. This question was approached in a sequence of modelling steps: First, we examined whether or not the measurement models of TEDDICS and CSE provided representations of the constructs that are invariant across gender. This step was necessary to ensure that potential gender differences in the relations between TEDDICS and CSE were not due to differences in the measurement of the two constructs (Millsap 2011). Specifically, we tested the three models of configural, metric, and scalar invariance. In the *configural invariance* model, the same factor structure is specified for female and male teachers, assuming that the same number of factors and links between manifest and latent variables are present. This model is the least restrictive and forms the basis for further invariance testing and model comparisons. Subsequently, item factor loadings were constrained to be equal across the gender groups, resulting in a model of *metric invariance*. If this model can be accepted, the relations among latent variables and to external variables can be compared. Finally, the item thresholds were constrained in the *scalar invariance* model. Establishing scalar invariance is considered to be the prerequisite for meaningful comparisons among the means of the latent variables (Byrne et al. 1989). However, for comparing the TEDDICS-CSE relations across gender, metric invariance is sufficient.

In order to decide on which level of invariance was achieved, model comparisons were conducted on the basis of χ^2 difference testing, and the differences in the goodness-of fit statistics (i.e., CFI, TLI, and RMSEA) between two invariance models were taken into account. In particular, we compared the metric and scalar model with the configural model and regarded changes of $|\Delta CFI| \leq .010$, $|\Delta TLI| \leq .010$, and $|\Delta RMSEA| \leq .015$ as insignificant (Cheung and Rensvold 2002). Hence, if the changes in these statistics were within the suggested cut-offs, the changes in the χ^2 statistics were rather low or insignificant. If the model also showed an acceptable fit, the more restricted invariance model was accepted. Gender differences in the resulting correlations were tested with the help of Wald's χ^2 test (Van de Schoot et al. 2012). Significant differences in the TEDDICS-CSE correlations point to the moderating role of gender. Please find a sample M*plus* code for the invariance testing in Additional file 1: B1.

Second, we investigated the moderation effects of age by establishing latent regression models with the TEDDICS factors as outcome variables, teachers' age, the CSE factors, and their interaction (Age × CSE) as predictors. In these analyses, age was *z*-standardized to avoid non-essential multicollinearity (Dalal and Zickar 2012; Marsh et al. 2014). The interaction between a latent CSE variable and the manifest age variable was established using the 'XWITH' and 'TYPE = RANDOM' options in M*plus* (Muthén and Muthén 1998–2015). These options are typically used to define interactions between either two latent variables or a latent and a manifest variable (e.g., Little et al. 2006). For specifying the interaction models, we used the robust maximum likelihood estimator (MLR) with corrected standard errors and χ^2 statistics in conjunction with Monte Carlo integration and 500 integration points. Given that this numerical integration method becomes computationally very demanding if a number of correlated latent variables are used simultaneously to create interaction terms, we decided to run the age moderation models for each of the three TEDDICS and CSE factors separately. Another argument supporting this decision is that the CSE factors are highly correlated resulting in multicollinearity when used as predictors in regression models. Although theoretically possible, we did not use the factor scores obtained from the TEDDICS and CSE measurement models to estimate the moderation effects. This approach could have resulted in heavily biased regression coefficients (Skrondal and Laake 2001). We notice that teachers' responses were treated categorically in all moderation analyses. Please find an example code for these models in Additional file 1: B2. If the 95 % confidence interval of the regression coefficient of the interaction Age × CSE did not contain zero, moderation was indicated (Marsh et al. 2014).

Third, teachers' gender was added to the moderation analyses, resulting in models with three single predictors (Age, gender, and CSE), three two-way interactions (Age × gender, Age × CSE, and gender × CSE), and a three-way interaction term (Age × gender × CSE). To decide on whether or not Age × gender moderated the TEDDICS-CSE relations, we inspected the 95 % confidence interval of the corresponding regression coefficient of the three-way interaction term.

Handling clustered and missing data

Due to the clustered data structure in ICILS 2013 (i.e., teachers are nested in schools), we adjusted the standard errors of the model parameters and the χ^2 statistics, using the MLR estimator and the 'TYPE = COMPLEX' option in *Mplus* for the moderation analyses. Furthermore, differences in the probabilities of being sampled as a teacher were accounted for by using teachers' sampling weights (M*plus* option 'WEIGHT = TEACHWT'; Asparouhov 2005). As mentioned earlier, teachers' responses were treated categorically using the WLSMV estimator for establishing the measurement models and testing for invariance across gender. This treatment also allows for the incorporation of the 'TYPE = COMPLEX' and weight options.

Among the teachers who responded to the TEDDICS and CSE scales, low proportions of missing values at the item level occurred (less than 1 %). Since these missing values were not due to the design of the study, we assumed that they were 'missing at random' and applied the full-information-maximum-likelihood procedure to handle them in the moderation models (Enders 2010). In the cases of using the WLSMV estimator, missing data were handled with the help of the pairwise deletion method (Asparouhov and Muthén 2010).

Results

Descriptive statistics and measurement models

The item descriptive statistics for both the TEDDICS and CSE scales are shown in Table 1. It is noteworthy that the teachers reported high levels of computer self-efficacy for most of the CSE items, as suggested by the means and the medians. Hence, statistical models that are based on a perfect normal distribution of the manifest indicators may not apply to CSE. We consequently decided to account for this deviation in subsequent analyses. For items belonging to the CSE factor of advanced operational and collaboration skills, the means of responses were lower than for the others. This result indicated that this factor may, indeed, present skills that are more demanding and difficult for teachers than others. However, these differences were by and large statistically insignificant, except for the most extreme mean differences (e.g., between items IT1G07A and IT1G07 M, t [1066] = –36.5, $p < .001$, $r = .07$), and only point to tendencies. In contrast, potential ceiling effects were not identified for the TEDDICS scale, as the means and medians were lower than the maximum scores of items. Nevertheless, we decided to be consistent in treating the data categorically and accounted for deviations from normal

Table 1 Descriptive statistics of the TEDDICS and CSE items

	M	SD	Mdn	Min	Max
Teachers' computer self-efficacy (CSE)					
IT1G07A	2.98	.16	3	1	3
IT1G07B	2.97	.19	3	1	3
IT1G07C	2.91	.34	3	1	3
IT1G07D	2.92	.30	3	1	3
IT1G07E	2.71	.51	3	1	3
IT1G07F	2.36	.73	3	1	3
IT1G07G	2.46	.65	3	1	3
IT1G07H	2.79	.51	3	1	3
IT1G07I	2.96	.24	3	1	3
IT1G07 J	2.91	.30	3	1	3
IT1G07 K	2.96	.20	3	1	3
IT1G07L	2.78	.47	3	1	3
IT1G07 M	2.25	.65	2	1	3
IT1G07 N	2.47	.71	3	1	3
Teachers' emphasis on developing students digital information and communication skills (TEDDICS)					
IT1G12A	2.93	.76	3	1	4
IT1G12B	2.83	.83	3	1	4
IT1G12C	2.94	.87	3	1	4
IT1G12D	2.87	.86	3	1	4
IT1G12E	2.74	.86	3	1	4
IT1G12F	2.46	.85	3	1	4
IT1G12G	2.97	.86	3	1	4
IT1G12H	2.40	.85	2	1	4
IT1G12I	1.91	.88	2	1	4
IT1G12 J	2.49	.88	3	1	4
IT1G12 K	2.77	.87	3	1	4
IT1G12L	2.70	1.00	3	1	4

$N = 1071$

distributions. After inspecting the descriptive statistics, we established the measurement models of TEDDICS and CSE.

TEDDICS measurement model

In a recently published study, which examined the validity of the TEDDICS scale in ICILS 2013 (Siddiq et al. 2016), it was shown that this scale comprised three correlated factors of teachers' emphasis on developing students' skills in accessing (factor 1), evaluating (factor 2), and sharing and communicating digital information (factor 3). We therefore based our assumptions on the structure of the construct on this finding, establishing a correlated-traits confirmatory factor-analytic model with three factors. This model fitted the data well, χ^2 (51) = 368.6, $p < .001$, RMSEA = .076, 90 % CI RMSEA = [.069, .084], CFI = .984, TLI = .980, and indicated sufficiently high factor loadings for each of the factors (TEDDICS factor 1: standardized $\lambda = .74–.83$, TEDDICS factor 2: standardized $\lambda = .84–.97$, and TEDDICS factor 3: standardized $\lambda = .67–.78$). Although the factor correlations were rather high ($\rho = .86–.90$; see Table 2), and a unidimensional model fitted the data only slightly worse, χ^2 (54) = 479.9, $p < .001$, RMSEA = .086, 90 % CI RMSEA = [.079, .093], CFI = .979, TLI = .974, $\Delta\chi^2$ (3, $N = 1071$) = 132.4, $p < .001$, we decided to keep the distinction between the three factors for substantive reasons. Specifically, we wanted to see how different aspects of TEDDICS related to CSE rather than examining this relation for an overall emphasis on developing students' skills in the context of ICT. In addition to establishing a three-factor measurement model for the total sample, we fitted the same model to the subsample of female and male teachers. As for the total sample, the model showed an acceptable fit for both *females*, χ^2 (51) = 251.5, $p < .001$, RMSEA = .076, 90 % CI RMSEA = [.066, .085], CFI = .987, TLI = .983, and *males*, χ^2 (51) = 179.8, $p < .001$, RMSEA = .081, 90 % CI RMSEA = [.069, .094], CFI = .980, TLI = .974. Hence, it can be used to study measurement invariance across gender and potential moderation effects of gender in subsequent analyses.

CSE measurement model

Following the same procedure, we specified a three-factor model for teachers' computer self-efficacy, assuming that CSE in basic operational ICT skills (factor 1), CSE in advanced operational and collaboration skills (factor 2), and, finally, CSE in using computers for instructional purposes (factor 3) can be distinguished. This distinction was also

Table 2 Correlations between TEDDICS, CSE, and teachers' age

Constructs	1.	2.	3.	4.	5.	6.	7.
1. TEDDICS: accessing	1.00	.90***	.89***	.15*	.21***	.37***	−.03
2. TEDDICS: evaluating		1.00	.86***	.19**	.21***	.40***	−.09*
3. TEDDICS: sharing & communicating			1.00	.23***	.28***	.41***	−.09*
4. CSE: basic operational skills				1.00	.77***	.74***	−.58***
5. CSE: advanced operational and collaboration skills					1.00	.77***	−.47***
6. CSE: instructional purposes						1.00	−.31***
7. Age in years							1.00

Correlations among latent variables are reported. $N = 1071$

* $p < .05$, ** $p < .01$, *** $p < .001$

based on prior research (e.g., Scherer and Siddiq 2015b). The resulting confirmatory factor-analytic model showed an excellent fit for the total sample, χ^2 [74] = 167.1, $p < .001$, RMSEA = .034, 90 % CI RMSEA = [.027, .041], CFI = .979, TLI = .974. As for the TEDDICS model, correlations among the latent variables were rather high (ρ = .74–.77; see Table 2); however, a unidimensional model fitted the data significantly worse, χ^2 [77] = 280.2, $p < .001$, RMSEA = .050, 90 % CI RMSEA = [.043, .056], CFI = .953, TLI = .945, $\Delta\chi^2$ [3, N = 1071] = 124.4, $p < .001$. Hence, we accepted the three-factor model as a measurement model of CSE, also because the loadings for each factor were reasonably high (CSE factor 1: standardized λ = .80–.99, CSE factor 2: standardized λ = .64–.79, and CSE factor 3: standardized λ = .83–.92). This model fitted the data well for *females*, χ^2 [74] = 136.0, $p < .001$, RMSEA = .035, 90 % CI RMSEA = [.026, .044], CFI = .968, TLI = .961, and *males*, χ^2 [74] = 121.6, $p < .001$, RMSEA = .041, 90 % CI RMSEA = [.027, .054], CFI = .988, TLI = .985. As a consequence, this model formed the baseline for further invariance testing across gender.

Correlations among the TEDDICS and CSE factors (Research Question 1)

To address Research Question 1, we combined the measurement models of TEDDICS and CSE, and examined the correlations among the latent variables. The combined model had an acceptable fit, χ^2 (284) = 504.1, $p < .001$, RMSEA = .027, 90 % CI RMSEA = [.023, .031], CFI = .987, TLI = .985, and indicated low to moderate correlations (ρ = .15–.41; Table 2). Since the resulting factor correlations were positive and significant (see Table 2), it can be concluded that higher levels of computer self-efficacy are associated with higher levels of emphasis on developing students' digital information and communication skills, and vice versa. The highest correlations occurred between the CSE factor of 'Self-efficacy in using computers for instructional purposes' and all TEDDICS factors (ρ = .37–.41). The lowest correlation was found between CSE in basic operational ICT skills and the TEDDICS factor of 'accessing digital information' (ρ = .15). In light of these findings, our response to Research Question 1 is: The factors of TEDDICS and CSE are positively correlated.

Moderation analyses (Research Question 2)

Moderation by gender

As mentioned earlier, measurement invariance is considered to be a prerequisite for comparing the TEDDICS-CSE correlations across gender. Since the baseline measurement models for both TEDDICS and CSE have been established successfully, further invariance models could be specified using multi-group confirmatory factor analysis. The results of invariance testing were clear-cut and suggested that the three invariance levels (configural, metric, and scalar) could be established (see Table 3). This was evident, because these models showed an acceptable fit to the data on the one hand, and indicated only small changes in the fit statistics, as compared to the configural model, on the other hand. In sum, comparing the relations between TEDDICS and CSE across gender was legitimate.

In order to investigate potential differences in the TEDDICS-CSE relations, we established a multi-group model that combined TEDDICS and CSE under the scalar invariance assumptions. The model fitted the data very well, χ^2 (626) = 898.9, $p < .001$, RMSEA = .029, 90 % CI RMSEA = [.024, .033], CFI = .985, TLI = .985, and was

Table 3 Fit indices and model comparisons of invariance testing with gender as the grouping variable (correlated-traits models)

Model	χ^2 (df)	CFI	TLI	RMSEA	90 % CI RMSEA	$\Delta\chi^2$ (Δdf)	ΔCFI	ΔTLI	ΔRMSEA
Measurement invariance models of TEDDICS									
Configural invariance	425.9 (102)***	.985	.981	.077	[.070, .085]	–	–	–	–
Metric invariance	427.9 (111)***	.986	.983	.073	[.066, .080]	14.2 (9) *ns*	+.001	+.002	−.004
Scalar invariance	424.1 (132)***	.987	.987	.064	[.057, .071]	47.6 (30)*	+.002	+.006	−.013
Measurement invariance models of CSE									
Configural invariance	258.5 (148)***	.982	.978	.037	[.030, .045]	–	–	–	–
Metric invariance	276.9 (159)***	.981	.978	.037	[.030, .044]	28.5 (11)**	−.001	.000	.000
Scalar invariance	311.7 (170)***	.977	.976	.039	[.032, .046]	77.3 (22)***	−.005	−.002	+.002

The configural invariance model was used as the reference for model comparisons. $N = 1071$

* $p < .05$, ** $p < .01$, *** $p < .001$, *ns* statistically insignificant ($p > .05$)

therefore accepted. To rule out that potential differences in the correlations were not due to differences in the factor correlations *within* the TEDDICS and CSE measurement models or differences in factor variances, we constrained these parameters in addition to the scalar invariance assumptions. These constraints led to a well-fitting multi-group model, χ^2 (632) = 908.3, $p < .001$, RMSEA = .029, 90 % CI RMSEA = [.024, .033], CFI = .985, TLI = .985, which was used for comparisons among the correlations. We compared the correlations among the TEDDICS and CSE factors by performing the Wald χ^2 test (Van de Schoot et al. 2012). Specifically, we first tested whether or not any differences in the correlations existed (overall test) and examined which specific correlations differed (local test) in a second step.

The pattern of relations for female and male teachers, by and large, corresponded (see Table 4). More specifically, all correlations except for the one between 'TEDDICS: Accessing digital information' and 'CSE: Basic operational skills' were positive and statistically significant. The overall Wald χ^2 test indicated that differences in the TEDDICS-CSE correlations, χ^2 (9) = 19.2, $p < .05$. Testing the differences in correlations with a stepwise procedure (i.e., local test) revealed that only the correlation between '*Sharing and communicating digital information*' and '*self-efficacy in using computers for instructional purposes*' was subject to gender differences in favour of female teachers, χ^2 (1) = 6.0, $p < .05$. The remaining correlations were similar across gender (see

Table 4 Correlations between TEDDICS and CSE across gender

Constructs	TEDDICS factors		
	Accessing digital information	Evaluating digital information	Sharing and communicating digital information
Correlations ρ			
CSE: basic operational skills	.19/.12	.14*/.31***	.28***/.43***
CSE: advanced operational and collaboration skills	.21*/.19**	.15/.27***	.37***/.43***
CSE: instructional purposes	.28/.21***	.30***/.31***	*.29***/.49****

Correlations among latent variables for the male sample are reported before the slash. Significantly different correlations are shown in italics. Differences in correlations were tested using the Wald χ^2 test (see Additional file 1: C1)

* $p < .05$, ** $p < .01$, *** $p < .001$

Additional file 1: C1). Although significant for only one correlation, there was a tendency toward stronger relations between the two TEDDICS factors of evaluating and sharing & communicating digital information and CSE for female teachers. As a consequence, given that only one of the TEDDICS-CSE correlations showed gender differences, moderation by gender was apparent to a limited extent.

Moderation by age

Investigating the moderation by teachers' age, we specified a series of models with an interaction between a CSE factor and age as a predictor of a TEDDICS factor (see Method section). The resulting information criteria of these nine models (3 TEDDICS factors × 3 CSE factors) are presented in Additional file 1: C2. Regarding the regression coefficients of the interaction term CSE × Age in these models, only two out of nine coefficients showed statistical significance, as their confidence intervals did not contain zero (see Table 5). This applied to the prediction of the TEDDICS factor 'Accessing digital information' and 'Sharing & communicating digital information' by 'CSE: Advanced operational and collaboration skills'. In these two cases, moderation by age was present; the coefficients were positive and therefore indicated that the relation between CSE and TEDDICS was stronger as age increased. Alternatively, it may also be concluded that the relation between age and TEDDICS was stronger for teachers' with high CSE than for teachers with low CSE.

Moderation by age × gender

Finally, we tested for three-way interaction effects by adding gender to the age moderation models. The corresponding information criteria of the nine models can be found in Additional file 1: C3. In none of the full models containing all possible interaction terms, it was possible to identify significant moderation by age × gender (see Table 6). Most of

Table 5 Regression models testing the moderation effects of teachers' age on the relation between TEDDICS and CSE

	TEDDICS factors (dependent variables)		
Predictors	**Accessing digital information**	**Evaluating digital information**	**Sharing & communicating digital information**
Estimate and 95 % CI			
Computer self-efficacy: basic operational skills			
Age	−.034 [−.240, .172]	−.167 [−.407, .073]	−.147 [−.377, .084]
CSE	.342 [−.704, 1.387]	.220 [−.385, .825]	.287 [−.005, .578]
Age × CSE	.270 [−.825, 1.365]	.196 [−.274, .665]	.038 [−.217, .294]
Computer self-efficacy: advanced operational and collaboration skills			
Age	.044 [−.180, .268]	−.078 [−.363, .207]	−.036 [−.253, .182]
CSE	*.244* [*.115*, *.372*]	*.313* [*.113*, *.513*]	*.397* [*.249*, *.544*]
Age × CSE	*.167* [*.037*, *.296*]	.169 [−.099, .437]	*.191* [*.026*, *.356*]
Computer self-efficacy: instructional purposes			
Age	.012 [−.188, .211]	−.100 [−.353, .153]	−.105 [−.310, .100]
CSE	*.273* [*.146*, *.399*]	*.352* [*.136*, *.568*]	*.360* [*.255*, *.465*]
Age × CSE	.101 [−.025, .227]	.065 [−.074, .205]	.082 [−.005, .168]

The table shows the unstandardized regression coefficients and their 95 % confidence intervals. Statistically significant coefficients are written in italics figures

Table 6 Regression models testing the moderation effects of teachers' age, gender, and their interaction on the relation between TEDDICS and CSE

Predictors Dependent variable	TEDDICS factors		
	Accessing digital information	Evaluating digital information	Sharing & communicating digital information
Estimate and 95 % CI			
Computer self-efficacy: basic operational skills			
Age	.079 [−.175, .334]	−.006 [−.064, .053]	−.076 [−.398, .247]
Gender	.984 [−.407, 2.375]	.037 [−.494, .568]	.637 [−1.016, 2.290]
CSE	.204 [−1.614, 2.021]	.012 [−4.144, 4.167]	1.824 [−4.052, 7.699]
Age × gender	−.015 [−.045, .015]	−.001 [−.009, .008]	−.010 [−.045, .025]
Age × CSE	1.065 [−.363, 2.494]	.277 [−3.736, 4.290]	*4.746 [.216, 9.276]*
Gender × CSE	6.204 [−3.933, 16.341]	1.993 [−32.942, 36.927]	38.501 [−2.049, 79.051]
Age × gender × CSE	−.123 [−.318, .072]	−.036 [−.620, .547]	−.739 [−1.539, .062]
Computer self-efficacy: advanced operational and collaboration skills			
Age	.129 [−.174, .432]	−.046 [−.462, .370]	.086 [−.233, .405]
Gender	.864 [−.255, 1.982]	.558 [−1.570, 2.685]	1.100 [−.623, 2.823]
CSE	.227 [−.069, .522]	.236 [−.158, .631]	*.493 [.207, .780]*
Age × gender	−.010 [−.035, .016]	−.001 [−.045, .042]	−.015 [−.051, .021]
Age × CSE	.247 [−.026, .520]	.103 [−.238, .443]	*.232 [.010, .453]*
Gender × CSE	.958 [−.605, 2.522]	−.148 [−1.944, 1.649]	.463 [−.890, 1.815]
Age × gender × CSE	−.018 [−.049, .013]	.008 [−.028, .043]	−.012 [−.040, .016]
Computer self-efficacy: instructional purposes			
Age	.118 [−.140, .375]	−.019 [−.404, .365]	−.049 [−.323, .225]
Gender	1.163 [−.396, 2.722]	.839 [−1.508, 3.186]	.738 [−.811, 2.287]
CSE	.205 [−.002, .412]	.300 [−.090, .690]	*.224 [.048, .400]*
Age × gender	−.016 [−.049, .018]	−.015 [−.062, .032]	−.009 [−.041, .023]
Age × CSE	*.121 [.005, .236]*	.153 [−.109, .414]	.159 [−.011, .330]
Gender × CSE	.365 [−.382, 1.113]	.401 [−1.224, 2.026]	.674 [−.376, 1.724]
Age × gender × CSE	−.005 [−.021, .010]	−.006 [−.037, .026]	−.009 [−.031, .012]

The table shows the unstandardized regression coefficients and their 95 % confidence intervals. Statistically significant coefficients are written in italics figures

the confidence intervals were rather large and contained zero. In addition to this finding, the information criteria of the age × gender moderation models (see Additional file 1: C3) were by and large higher than those of the age moderation models (see Additional file 1: C2), suggesting that adding gender and further interaction terms may not necessarily improve the fit of the model. Hence, we conclude that there is not enough evidence to argue for an age × gender moderation of the TEDDICS-CSE relations.

Taken together, with respect to Research Question 2, our findings suggested that gender and age moderation were present for some of the TEDDICS-CSE relations; yet, the age × gender moderation could not be identified.

Discussion

The aim of the current study was to deepen the understanding of how teachers' self-efficacy in using computers is related to their emphasis on developing students' digital skills (Research Question 1), and to what extent age, gender, and their interaction moderate this relation (Research Question 2). Applying structural equation modelling, we found support for positive and significant relations between the three factors of TEDDICS and the three CSE factors. Furthermore, for comparing the TEDDICS and CSE relations across gender, scalar invariance was established. On the basis of the invariant model, we provided evidence for the moderating role of gender, indicating at least one significantly higher TEDDICS-CSE correlation favouring female teachers. Further analyses showed moderation effects of age on two TEDDICS-CSE correlations, indicating a stronger relation as teachers' age increases. Finally, the moderation effects of age × gender could not be identified.

The relations between TEDDICS and CSE factors (Research Question 1)

An in-depth view was provided by examining the TEDDICS-CSE relations for the three facets of TEDDICS and the three facets of CSE. The results support our assumptions of positive relations between the two constructs, meaning that teachers who believe in their competences related to use of computers also emphasize developing their students' digital skills in their classroom more. Interestingly, the highest correlations were identified between all three TEDDICS factors and the CSE factor 'Using computers for instructional purposes'. This CSE factor is related to teachers' beliefs in their competence of using computers in classroom settings (Scherer and Siddiq 2015b). Whereas the other two factors of CSE refer to operating computers at different levels of competence (basic operational, and advanced operational and collaboration skills), the instructional CSE factor reflects the embedment of computers in instructional settings and for teaching purposes. As a consequence, the significant correlations between this factor and the three TEDDICS factors may be due to their commonalities in focusing on instructional activities. Nevertheless, the correlations are moderate, suggesting that TEDDICS and CSE are still distinct and take different perspectives on teaching and learning with computers (Siddiq et al. 2016). This finding supports the notion that CSE should not be studied as a *general* construct but rather refer to more *specific* capabilities of using computers, for instance, in classroom settings (Dicke et al. 2014).

The correlations between the three factors of CSE were moderate, whereas the correlations between the three factors of TEDDICS were rather high (Table 2). As a consequence, the three TEDDICS factors showed similar correlations with the CSE factors. This finding indicates that the differentiation of TEDDICS is not clearly evident in this sample of Norwegian teachers. One explanation may be that teachers who emphasize the development of students' ICT skills in one of the three hypothesized factors may out emphasis on the other factors to the same extent. In fact, the digital skills proposed in the TEDDICS framework are closely related and might reflect a process rather than a set of skills (Siddiq et al. 2016). Another explanation may lie in the fact that each of the factors contained only a limited number of items, which may not necessarily provide enough indicators in order to distinguish between the three TEDDICS factors. We therefore suggest developing and empirically investigating alternative and more extended measures of the TEDDICS construct.

It must be noticed that the positive TEDDICS-CSE relations advocate that if teachers are expected to instruct students in order to improve their digital skills, self-confidence in their own digital skills may be beneficial in order to meet these instructional expectations (e.g., Niederhauser and Perkmen 2010). Henceforth, teachers that do not see themselves as competent in these matters are less likely to emphasize the development of students' digital and information skills. This finding can be discussed generally in the context of teachers' self-efficacy and their instructional practices. Specifically, Holzberger, Philipp, and Kunter (2013) showed that teachers' general self-efficacy outside the context of ICT is related to their instructional behaviour, even in a longitudinal perspective. Tschannen-Moran and Woolfolk Hoy (2007) present a slightly different perspective on this relation: They propose a number of sources of self-efficacy, of which the most important one refers to the mastery experience people make. As such, positive (mastery) experience in specific tasks may increase people's self-efficacy in these tasks. Transferring this general argumentation into the ICT context, we argue that teachers who design instructional settings in order to emphasize the development of students' digital skills may make mastery experience in such scenarios, which in turn could strengthen their self-efficacy in using computers for instructional purposes in the future.

Given the undeniable importance of self-efficacy even in the context of ICT, one may stress the necessity of teacher training programs being closely related to hands-on teaching practice in their subject domains in order to strengthen their computer self-efficacy (Hennessy et al. 2005; Scherer and Siddiq 2015b). Finally, our findings are in line with previous research on CSE as a significant predictor of teachers' use and implementation of ICT in classrooms (Akarsu and Akbiyik 2012; Chen 2010; Teo 2008).

The moderating roles of age, gender and their interaction (Research Question 2)

Gender effects

The premise of an invariant measurement model was met and facilitated further analyses for comparing male and female teachers. Acquiring evidence of measurement invariance is vital for assuring that the measures do not act differently across gender groups (Scherer and Siddiq 2015b). Based on this premise, significant gender differences in favour of female teachers were identified for only one out of nine TEDDICS-CSE correlations. Since gender effects were not found for all nine TEDDICS-CSE relations, our findings suggest that male and female teachers may differ in some matters related to ICT to a limited extent. Nevertheless, previous research in ICT-related investigations provided contradicting findings on the existence of gender differences (Durndell and Haag 2002; Pamuk and Peker 2009; Shapka and Ferrari 2003; Sieverding and Koch 2009). Furthermore, previous research did not find evidence on differences across gender for the TEDDICS construct (Siddiq et al. 2016), and only partly for CSE (Scherer and Siddiq 2015b). Accordingly, our results provide only limited evidence of gender effects in particular ICT contexts.

Specifically, the relation between the TEDDICS factor 'Sharing & communicating digital information' and the CSE factor 'Using ICT for instructional purposes' was stronger for female teachers than for male teachers. This result points toward the belief that female teachers may lack confidence in their competences in using computers for teaching (Scherer and Siddiq 2015b; Sieverding and Koch 2009), and consequently put less emphasis on developing students' ICT-related skills. The other two CSE factors in this study are to a larger degree related to teachers' use of computers for personal matters. Hence, these findings suggest that the gender gap related to CSE in general is narrowing.

Although, it is apparent that there are differences between female and male teachers regarding to what extent they feel confident to integrate ICT in their teaching practices, namely their technological pedagogical content knowledge (Koehler and Mishra 2009). However, it may also mirror results from existing studies which revealed that male and female teachers' respond differently when evaluating their ICT competences. Male teachers tend to regard themselves as more competent and female teachers are more inclined to underestimate their own competence (Cooper 2006; Ong and Lai 2006). Our findings indicate that the influence of computer self-beliefs is, to some extent, subject to gender differences.

Age effects

The age effects identified in our study indicate that some of the TEDDICS-CSE relations tend to be stronger for older teachers than for their younger colleagues. In other words, the influence of the CSE factor related to advanced-operational and collaboration skills on the two TEDDICS factors 'Accessing digital information' and 'Sharing & communicating digital information' is more important for teachers of higher age. However, since the ICILS 2013 data do not allow causal interpretations of the direction of these relations, alternative explanations may exist. For example, we may also conclude that the relations between age and the two TEDDICS factors were stronger for teachers with high CSE than for teachers with low CSE. Either ways, our results agree with prior research by showing that teachers' age plays a noteworthy role in their ICT use and self-beliefs (O'Bannon and Thomas 2014; Scherer et al. 2015; Vanderlinde et al. 2014).

Age × gender effects

Finally, as the interaction effects between teachers' age and gender did not moderate the TEDDICS-CSE relations, we do not have evidence that the moderation by gender was specific to certain age groups, and the moderation by age was not sensitive to gender differences. It therefore seems as if the standalone effects of age and gender dominate the moderation. Nevertheless, the identification of such complex moderations is often subject to high standard errors and broad confidence intervals (Afshartous and Preston 2011). Moreover, the incorporation of further interaction terms (e.g., CSE × gender, CSE × age) increases the complexity of the regression model and may introduce essential multicollinearity (Marsh et al. 2014). As a consequence, we need to consider these findings in light of the methodological complexities.

Limitations and future directions

The present study has a number of limitations that point to future research: First, we only investigated the relations between CSE and TEDDICS. Future research may study these constructs as part of a bigger framework such as the technology acceptance model (Ong and Lai 2006), in which further measures related to ICT attitudes, use, and beliefs are included (e.g., perceived usefulness of ICT; Scherer et al. 2015). Second, we restricted our analyses to the Norwegian context, in which ICT plays an important role in school curricula (Norwegian Directorate for Education and Training 2012). It would therefore be interesting to examine the generalizability of our findings across further countries and educational contexts. In fact, taking an international perspective on the measures of and relations between CSE and TEDDICS may provide information on their differences and similarities. Finally, only a limited number of items were assigned to the three facets of TEDDICS; this design issue may have caused the considerable high correlations among the TEDDICS factors. We therefore suggest putting further effort into the development of items and in investigating the extent to which a broader TEDDICS assessment is able to differentiate between the three hypothesized factors. Moreover, it still needs to be disentangled how well the TEDDICS facets can be used to inform teacher professional development and practice.

Conclusions

In light of the findings the present study has revealed, we first conclude that teachers' computer self-efficacy plays a significant role for their emphasis on developing students' digital and information skills in classroom settings. This finding suggests that feeling competent in using ICT for instructional purposes may be regarded as a prerequisite for emphasizing the development of students' ICT skills. Hence, teacher training intuitions may emphasize the development of teachers' technological pedagogical content knowledge to enable and strengthen their competence of ICT integration in classroom activities. Second, we showed that the TEDDICS-CSE relations are, to some extent, subject to gender and age effects. This finding suggests that the importance of CSE for TEDDICS does not distribute equally between males and females, and across age groups. This may point to the need for designing teacher training programs that are aimed at fostering CSE and specifically take into account gender and age variation. We conclude that this study provides knowledge that could benefit teacher training programs, and may be further useful for designing teacher development material which takes in account that female teachers may have lower confidence in their technological pedagogical content knowledge.

Additional file

Additional file 1. Additional material.

Abbreviations

AIC: Akaike's Information Criterion; BIC: Bayesian Information Criterion; CFI: comparative fit index; CI: confidence interval; CSE: computer self-efficacy; *df*: degrees of freedom; ICILS: international computer and information literacy study; ICT: information and communication technology; MLR: robust maximum likelihood estimator; RMSEA: root mean square error of approximation; TEDDICS: teachers' emphasis on developing students' digital information and communication skills; TLI: Tucker Lewis index; ω: McDonald's ω (reliability coefficient); WLSMV: weighted least squares means and variance adjusted estimator.

Authors' contributions

FS prepared the data, participated in the process of developing a rationale, drafted the background and discussion sections of the manuscript, and revised earlier versions of the manuscript. RS led the modeling process, drafted the methods and results sections, and revised earlier versions of the manuscript. Both authors read and approved the final manuscript.

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Competing interests
We confirm that this manuscript has not yet been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with its submission to *Large-scale Assessments in Education*. Furthermore, the authors accept the copyright information and the Springer author's rights. The authors declare that they have no competing interests.

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